SHRINKAGE BEHAVIOUR OF KAOLIN ENHANCED WITH SUPERABSORBENT POLYMER

NOR YUSNITA BINTI YAACOB

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering (Hons.).

_____

(Supervisor's Signature)

Full Name : DR. HJ MOHD YUHYI BIN HJ MOHD TADZA

Position : SENIOR LECTERUR

Date : 25th JUNE 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : NOR YUSNITA BINTI YAACOB

ID Number : AA12103

Date : 25th JUNE 2018

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NOR YUSNITA BINTI YAACOB

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ABSTRAK

Jumlah pelupusan sampah yang banyak ke tapak pelupusan setiap hari boleh menyebabkan masalah alam sekitar ke tapak pelupusan sampah. Tanah liat boleh menjadi salah satu penyelesaian masalah alam sekitar yang boleh digunakan untuk aplikasi geo-alam sekitar seperti halangan tanah liat, halangan tambak dan boleh bertindak sebagai rawatan dan kawalan sisa. Kaolinite mempunyai keplastikan yang lebih rendah selain ia ada di dalam negara dan mempunyai kos yang lebih rendah berbanding beberapa jenis tanah liat seperti bentonit, illite dan montmorillonite. Tingkah laku kaolinit pengecutan akan dikaji dengan menggunakan Ujian Clod. Peningkatan Super Penyerap Polimer (SAP) dapat membantu meningkatkan prestasi susunan pengecutan kaolinit kerana ia mempunyai penjerapan tinggi dan pengekalan cecair. Objektif kajian ini adalah untuk menguji tindak balas pengecutan kaolinit yang dipertingkatkan dengan SAP dan untuk mendapatkan lengkung pengecutan nisbah kekosongan berbanding kandungan air menggunakan Ujian Clod.

ABSTRACT

Huge amount of waste disposal to landfill every single day can cause environmental problem to landfill. Clay can be one of the solution the environmental problem which it can be used for geo-environmental application such as clay barriers, landfill barriers and can act as treatment and waste control. Kaolinite has lower plasticity besides it is locally available and has lower cost compared to a few other types of clay such as bentonite, illite and montmorillonite. Shrinkage behaviour of kaolinite will be studied by applying Clod Test. Enhancement of Super Absorbent Polymer (SAP) can help to improve the performance of shrinkage behaviour of kaolinite as it has high adsorption and retention of fluids. The objectives of this study are to test the shrinkage behaviour of kaolinite enhanced with SAP and to obtain shrinkage curve of void ratio versus water content using Clod Test.

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CHAPTER 1

INTRODUCTION

1.1 Background

Waste water are generated daily in form of solid, sludge, liquid or gas (Bouzza & Van Impe, 1998). Increasing in number of population for a developing country in Malaysia will inevitable produce more wastes that need to be disposed. Disposal of these wastes need to be carried out in a proper way to ensure the safety of the environment. One of the methods of waste disposal is by permanent disposal at landfill sites (Ayomoha et al., 2008). A proper landfill should be able to contained waste at the same time preventing the migration of pollutants into the environment. In order to obtain the best waste disposal practices, waste characterization must be undertaken prior to designing a landfill.

Landfill is built up with layers of solid waste and covered with soil or bottom liner to prevent ground water pollution. A landfill is designed in order to minimize public health and environment impacts. The main feature of sanitary landfill is that a liner is designed at the bottom of landfill (Baghci, 2004). According to Qian et al., (2002), liner system in landfill acts as a barrier against the advective and diffusive transport of leachate. In addition, in addition liner system in landfill consist of multiple barrier and drainage layers (Qian et al., 2002). Clayey soils are widely used as liner material for landfills. Clayey soil is used to liner material due to its low hydraulic conductivity (k) and sorptive properties (Owies and Khera, 1998). In some cases, geosynthetic clay liners (GCL) containing bentonite and geotextile are used (Sharma and Reddy, 2004). Furthermore, the use of natural soil containing kaolinite minerals is a cheaper alternative.

Clay exhibit swelling and shrinkage behaviour when objected to wetting and drying process (Hsai-Yang and Daniels, 2006). In landfills, clay liners received water when in contact with groundwater or stormwater that infiltrate into the landfill which in turn caused the liners to swell. Upon drying, soil containing clay mineral undergoes shrinkage process and reduction in volume with water content changes. Shrinkage behaviour of clays can cause damage to structures built on or with clays (Sivapullaiah et al., 1986). During the dry periods, clayey soil will shrink and form cracks (Sivapulliah et al., 1986). Significant shrinkage and excessive formation of crack cause problem to the landfill. Thus, shrinkage behaviour is important for long-term assessment of engineering behaviour of clays. It is very important to determine the shrinkage behaviour of soil. Studies relating to shrinkage behaviour of soil have been shown to be useful in assessment of stability of clay barriers (Tang et al., 2008). In order to determine the shrinkage characteristic of clay soil, volume measurement of soil during dying is required. Generally, duplicate soil specimens are prepared and tested in the laboratory for this purpose. However, this process is tedious and time consuming (Head, 2006).

Bentonite is one of the suitable example of backfill materials in decreasing and maintaining the low grounding resistance of electrodes (Lim et al., 2015) for a long time due to its high water absorption and retention tendency (Lim et al., 2013). It is a natural material that is composed predominantly of the clay mineral smectite which able to swell when in contact with free water (Keto 2004). Bentonite is hydrate where it acts as drying agent to draw moisture from surrounding environment into its structure and holds the water chemical (Jones, 1980). In Malaysia, it was reported that bentonite only deposited in several areas of Sabah such as in Segama, Sepagaya, Mansuli and Andrassy (Samsuri,2006). According to Malaysia minerals Yearbook 2010, there are three bentonite processing plants in Malaysia which located one each in Perak, Johor, Selangor but all are raw bentonite are imported. In 2010, Malaysia imported 73,269 tonnes of bentonite mostly from india, Chin, USA, Australia and Germany which cost up to RM61,203,000.

Kaolinite is another type of clay which deposited in Malaysia at the state of Perak, Johor, Kelantan, Selangor, Pahang and Sarawak and around 112 million tons of kaolin have been discovered throughout the country (Baioumy et al., 2012). According to Malaysian Minerals Yearbook 2010, kaolin production in that year increased to 530,331 tonnes from 487,632 tonnes recorded in the previous year mainly in Perak. However, kaolinite has lower plasticity behaviour than bentonite. According to research by Horpibulsuk et al., (2011), bentonite has very high plasticity index which 175% but the plasticity index for kaolin is very low which is 22%. Another study also showed that bentonite has 91.8% plasticity index but kaolin only has 15.5% of plasticity index (Imai, 1980). Besides that, bentonite has higher optimum water content compare to kaolin due to bentonite's high sportive force from its surface electrical chargers. It is also stated that bentonite has optimum water content up to 37% but kaolin only has 19.5% of optimum water content (Fattah et al., 2016).

Superabsorbent polymer (SAP) is a hydrogel with three-dimensional polymer networks that expand when absorb water (Mudiyanselage et al., 2008). SAP is applied widely in several sector such as enhanced oil recovery, mine waste treatment, sludge dehydration, strengthening of concrete and soil amelioration (Gao,2003). Gao state that SAP improve the soil quality for plant growth by absorbing water from rainfall or irrigation and releasing it slowly. SAP able to absorb more than hundred times of water than its own weight rapidly and retain water well even at high temperature and pressure (Guan et al., 2017).

Literature suggested that, the use of several soil parameters can be used to establish the soil shrinkage characteristic curve according to Chertkov, (2000). By using parameters such as water content and specific gravity, the entire shrinkage curves at any given water content can be establish for a given soil. Various researchers in the past have proposed models such as ModGG model, ModC model, OH model, TD model, Gea model, Bea model, Kea model, MM2 model and MM1 model can be used to establish the soil shrinkage characteristic curve (Cornelis et al., 2006). As the shrinkage curve of soils is generally nonlinear in nature, a number of equations are used to

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